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Procedia Engineering 44 (2012) 202 – 203

Procedia Engineering

www.elsevier.com/locate/procedia

Euromembrane Conference 2012

[OB08]

Water recovery from waste gaseous streams: An application of hydrophobic membranes

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The recovery of water through the condensation of humidified waste gaseous streams by using condensing heat exchangers has the main problem of corrosion. On the other hand, the regeneration of the desiccant and the low quality of the produced water are the disadvantages in the use of a desiccant drying system for the removal of water vapor from gas streams.

In the present work, microporous hydrophobic membranes for the selective recovery of evaporated waste water from industrial gases are instead utilized. In particular, the hydrophobic membranes are employed in a *membrane condenser* (Figure 1). In the proposed system, the feed (super-satured industrial gas) is brought into contact with one side (retentate side) of a hydrophobic, microporous membrane. The hydrophobic nature of the membrane prevents the penetration of the liquid into the pores while the gases pass through the membrane. Therefore, the liquid is recovered from the retentate side of the membrane, whereas the dehydrated gases from the permeate side of the membrane.

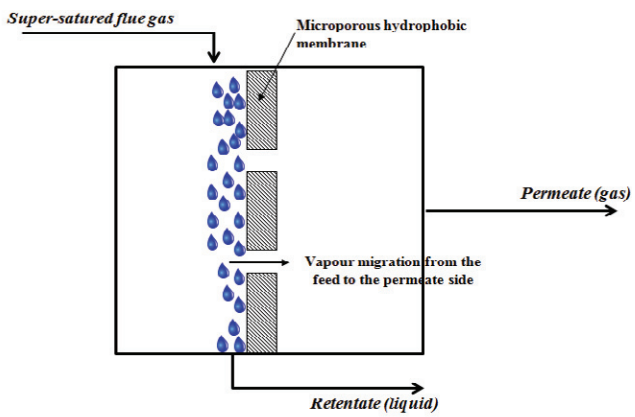

Figure 1. Scheme of the membrane condenser process.

The process is characterized by a very low pressure difference between the two membrane sides. A simulation study of the process has been carried out for predicting the membrane-based process performance in terms of fraction and amount of recovered water, in dependence of the effect of temperature and relative humidity of the inlet flue gas. The achieved results indicate that a 20% water recovery (the amount to make the plant self sufficient) can be achieved with temperature reductions less than 5°C if flue gas is in common conditions (i.e., 50°C < T < 90°C and 90% < RH < 100%). To verify the results achieved by the simulation analysis a membrane module with PVDF commercial membranes (supplied by MEMBRANA GmHB) has been prepared and its performance has been evaluated in an artificial flue gas stream. The experimental results have been compared with the ones achieved through the simulation (Figure 2).

doi:10.1016/j.proeng.2012.08.358

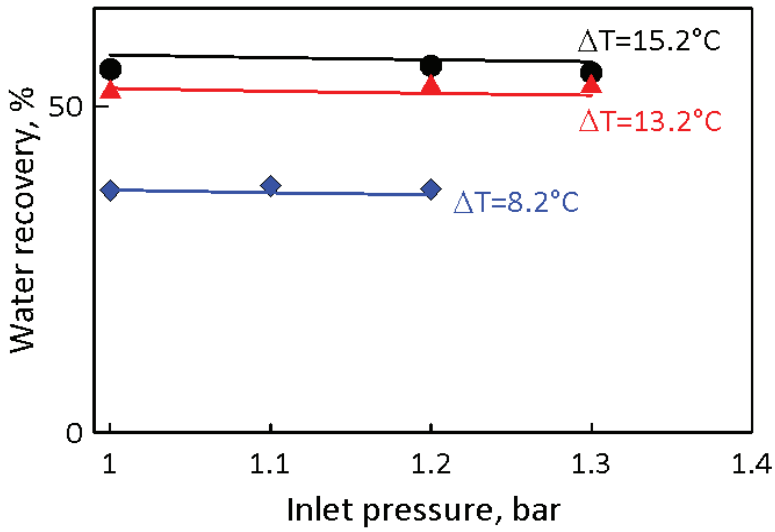

Figure 2. Recovered water vs feed pressure. Flue gas with RH_{Feed}=100%, T_{feed} = 55.2°C and 1 bar < P < 1.3 bar.

In the graph, the fraction of recovered water with respect to the feed pressure and at various temperature reductions is shown. Flue gas with a temperature equal to 55.2°C has been considered. In the figure, the lines are referred to the simulations, the points to the experimental measurements. It can be observed a good agreement between experimental tests and model, with deviations less than 2.24%. This confirms the validity of the simulation study done and its suitability for a preliminary screening of the potentialities offered by the membrane condenser in the dehydration of gaseous streams.

Acknowledgments

The EU-FP7 is gratefully acknowledged for co-funding this work through the project *"CapWa - Capture of evaporated water with novel membranes"* (GA 246074). We also wish to acknowledge Dr. Wolfgang Ansorge (Membrana GmbH) for supplying us samples of hollow fibres PVDF membranes.

Relevant bibliography

F. Macedonio, A. Brunetti, G. Barbieri, E. Drioli, Membrane Condenser as a new technology for water recovery from humidified "waste" gaseous streams. IECR, 2012. (Submitted)

Keywords: Membrane Condenser;, Hydrophobic Microporous Membrane, Dehydration